Chemical Mixture Test Program in Snow and Ice Control

C. H. LANG, Chief Engineer, New York State Thruway Authority; and
W. E. DICKINSON, Chief Engineer, Calcium Chloride Institute

● DURING THE WINTER of 1958-59, the New York State Thruway Authority, in conjunction with the Calcium Chloride Institute, conducted a research program on the use of chemical mixtures of calcium chloride and rock salt in winter maintenance. Previously, rock salt and sand abrasives were relied on to combat the winter storm conditions.

The Weedsport Maintenance Section was selected as the test area for using calcium chloride along with salt and abrasives, the purpose was to obtain (a) information on faster and more effective melting action; (b) data on economy of materials; and (c) information on handling, storing, and applying calcium chloride mixtures.

Weedsport Maintenance Section extends from MP 289 to MP 321 (approximately 32 mi). To determine the effect of the calcium chloride, in this test program, results in a 10-mi portion of the Syracuse Maintenance Section (MP 279 to MP 289) and in a 10-mi portion (MP 321 to MP 331) in the Manchester Section were compared to results in the Weedsport Test Section. Both the Syracuse and Manchester Sections were instructed to carry out their normal winter maintenance procedures using salt and abrasives. Report forms were filled out by supervisory personnel, noting weather and pavement conditions during storms in each test area. These reports, plow operator's reports, and summary reports from Section Supervisors were collected after each storm.

Calcium Chloride Institute recommended a mixture ratio of one part calcium chloride to three parts of rock salt by weight (1:3) for the chemical mixture. It was more practical to proportion and mix the two chemicals by volume in the field and a ratio of one part calcium chloride to two parts of salt (1:2) by volume was determined approximately the same. This mixture (with some variations and with different proportions of abrasives) was used in the snow and ice operation.

STORAGE OF BULK CALCIUM CHLORIDE

For the storage of the bulk calcium chloride, a wood frame structure of 80-90 tons capacity was added to an existing concrete block salt storage shed, utilizing one side wall of the salt shed. The storage shed front was rigged with an adjustable canvas, raised to unload or lowered to protect the calcium chloride from the weather. The 16-ft shed allowed adequate area for the belt conveyor to be backed into the shed while unloading calcium chloride. (No difficulties were encountered with crusting or hardening of the calcium chloride during the winter.)

HANDLING AND MIXING CHEMICALS

The normal method of loading the hoppers on the highway spreaders is with a ¾-yd front-end loader. The first method was as follows: bucket loads of calcium chloride, salt and abrasives were loaded into the spreaders in desired proportions; spreaders were loaded with alternate layers of calcium chloride, salt, and abrasives.

This method was not entirely satisfactory. It slowed loading time during a storm and confused the pay loader operator who was instructed to load materials from three piles in different proportions. A thorough mixing of chemicals was not obtained resulting in an uneven distribution of materials on the road.

The second method included premixing a stockpile of calcium and salt between storms with a front-end loader and a better mixture was obtained. It was handled a second time when loaded into the spreader which furthered the mixing.

The third and most effective mixing method was with the belt conveyor. It was

rigged with two hoppers: one was permanently bolted to the conveyor; a second hopper, on skids, was placed over the conveyor belt. Calcium chloride was loaded into one hopper and salt into the second; gates on each hopper were adjusted to obtain desired mixture. This resulted in a thorough, evenly distributed mixture which was then stockpiled prior to storms.

FINDINGS OF THE CHEMICAL MIXTURES TEST PROGRAM

The following conclusions were made after observing the use of calcium chloride and salt mixtures in the Weedsport Maintenance Section for the past winter:

1. The chemical mixture has a much faster melting action than straight salt. This action results in a bare pavement sooner (with a comparable reduction in time and use of equipment). The farther the temperature dropped below 30F, the greater was the difference in time of melting action between the chemical mixture and the straight salt, favoring the mixture.
2. With temperatures in the mid 20's after a storm ends, the pavement was cleaned in 15 to 20 min after spreading the chemical mixture.
3. The chemical mixture used with abrasives holds them to the pavement. It prevents the abrasives from being swept off by the wind and traffic much better then straight salt.
4. With a sudden drop in temperature, and slush on pavement, when using rock salt, the pavement can become glazed, thus requiring an additional application of salt to obtain a dry pavement. By using the chemical mixture no glazing occurred when similar temperature conditions were encountered.
5. Weedsport increased by about 20 percent the spread of chemicals per truck over that obtained with straight salt due less throw off and bounce. Formerly, the maximum spreading speed was about 25 mph. With mixtures, the spreading speed was increased to 30 mph. This speed increased the length of spread from an average of 15 to 18 mi. It decreased the amount of materials spread from about 750 lb per mi to 600 lb per mi.
6. A premixed (25-30 tons) stockpile of calcium chloride and salt was prepared during fair weather for use during the early part of storm. No protection from the weather was necessary. Crusting did not occur except after a rain, when the premixed pile developed a 2-in. thick crust easily broken during later handling. Several times this type stockpile was successfully kept for over a week before using.
7. A satisfactory mixture for most all storm conditions was two parts mixed chemicals (1:3 calcium to salt, by weight) mixed with one part abrasives. This mixture was nearly as effective in melting action as clear chemical and provided abrasives for skid protection. This mixture is more economical than using straight salt and better results were obtained with it.
8. One observation noted from the use of calcium chloride with rock salt is the lack of visible salt residue, which with straight rock salt, is deposited on pavement and shoulders. This salt residue is apparent on the pavement for several days after a storm; it was, as late as spring, still obvious on the shoulders and mall along the pavement edge in Syracuse and Manchester Sections. It is assumed that it was because of the use of calcium chloride that very little of this salt re-crystallization was noted in the Weedsport Section.
9. It was found that spreaders could not be kept standing loaded with calcium chloride and salt for more than several hours in a warm garage without caking starting to occur in the spreader box. Therefore, spreaders were not preloaded with the chemical mixture. Immediately after a storm, each truck, spreader, and spreader box was rinsed free of all calcium and salt.
10. Some difficulty was encountered by calcium chloride caking on the wires of unprotected spreader motors, and motors of equipment used to load calcium chloride, by shorting the ignition. For this reason, there was difficulty at times starting equipment previously used. This difficulty was corrected to some extent by (a) covering openings around the spreader motor, such as around the exhaust pipe; and (b) by washing down the equipment with hot water after use.

COST STUDIES

While it has been found that many benefits are obtained from using calcium chloride during winter operations, the second reason for this test program was to determine the economics of using calcium chloride. Tables have been prepared showing comparisons between the three maintenance sections (Syracuse, Weedsport, and Manchester) for the past several years and attempts have been made to establish what, if any, savings were realized. Note that there are many variables between each section as to traffic and weather conditions, particularly in weather conditions from one section to another and from year to year.

The winters in which there are many repeated snow storms and squalls are the years in which the salt consumption is the highest if the average temperatures are the same (Fig. 1). Often a storm producing 2 to 3 in. of snow will require as much salt to be spread as a storm producing 12 in. However, another factor in the amount of salt consumption is the variant winter temperatures. During the winter of 1957-58, the average temperature in the Syracuse Section for the months of December through March was 27.4F. During the same period in 1958-59, the average temperature was 23.3F, an average temperature drop of 4.1F. Although the average number of days of snowfall and the total snowfall for the two seasons were about the same, during the 58-59 season, the consumption of salt in the Syracuse Section was 620 tons greater.

In Rochester, New York, the average temperature was 27.8F during the 1957-58 winter and 24.0F during the 1958-59 season; a lower average temperature of 3.8F

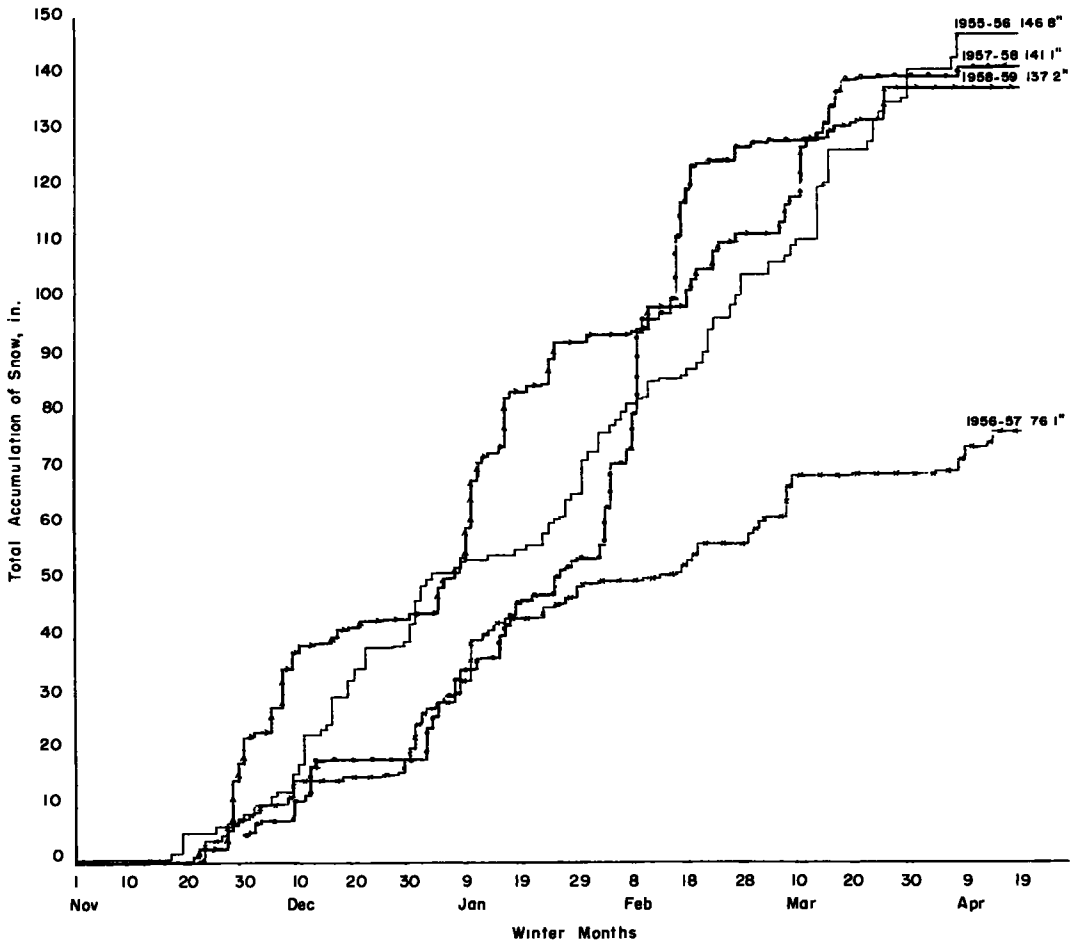

Figure 1. Accumulation of snowfall - weather station at Hancock Field, Onondaga Co. Data for calcium chloride test program.

TABLE 1

COMPARISON OF SALT AND ABRASIVES USED ON HIGHWAYS FOR WINTER MAINTENANCE

Section	Tons of Salt Used on Highway During Winter of 1957-58	1958-59	Increase 1958-59 Over 1957-58 Tons	%	Estimated Tons of Salt Weedsport Would Have Used in 1958-59 Tons	%	Tons of Abrasives Used During 1957-58	1958-59	Tons Change 1958-59 vs. 1957-58
Syracuse division	12,650	15,490	2,840	22.5	4,408	22.5	-	-	-
Syracuse	2,610	3,230	620	23.8	4,210	17.3	4,345	3,500	- 845
Weedsport	3,590	3,810[1]	220	6.1	-	-	3,440	3,720	+ 280
Manchester	2,350	3,230	880	37.5	4,470	24.5	2,025	3,500	+1,475

[1] 3,810 tons includes 3,040 tons rock salt and 770 tons of Calcium chloride.

during the 1958-59 season (Fig. 2). The salt consumption (adjacent to Rochester) in the Manchester Section was 880 tons greater during the 58-59 season.

It seems reasonable to conclude that lower temperatures encountered during the season of 1958-59 at both Syracuse and Rochester resulted in a greater use of salt.

Table 1 gives the summations of the total amount of salt used on the Thruway in the three sections for the past two years. Columns 3 and 4 show the tons and percent increase of 1958-59 over 1957-58's consumption. The Syracuse Division salt consumption for highways (1958-59) increased by 2,840 tons, a 22.5 percent increase over 1957-58. On this basis, Weedsport would have used an estimated 4,408 tons of straight salt. Likewise by comparing with the Syracuse Section and adding their tons increase to the Weedsport total for 1957-58, 4,210 tons is estimated or a 17.3 percent increase, if straight salt were used. By comparison with the Manchester Section, a total of 4,470 tons is netted, or a 24.5 percent increase. Averaging these last two figures,

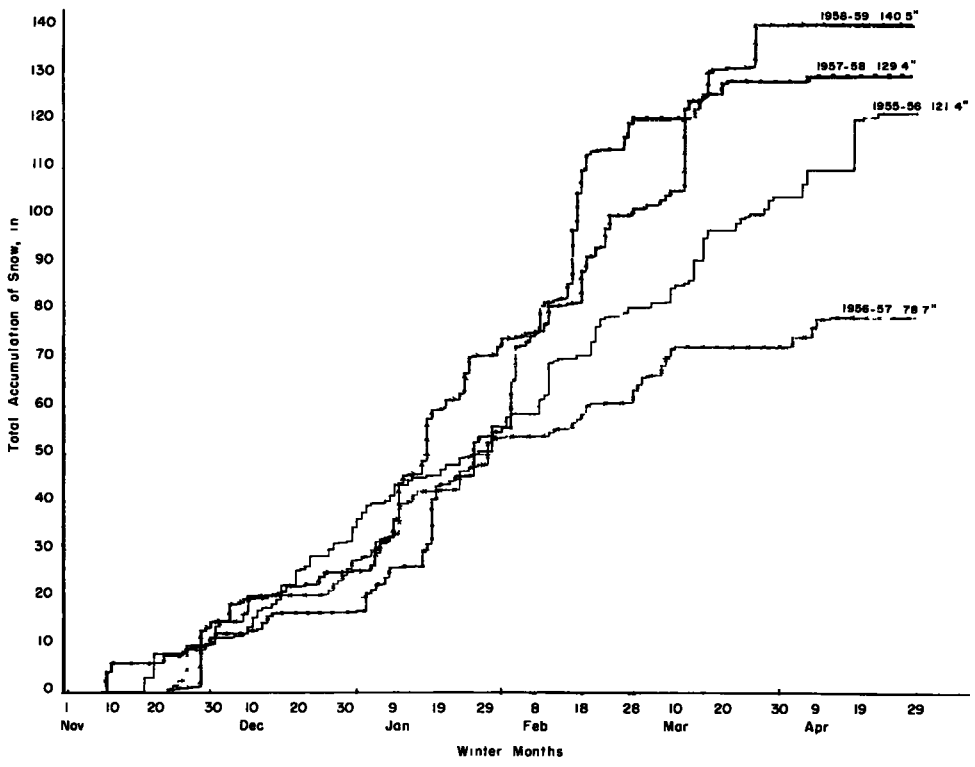

Figure 2. Accumulated snowfall in Rochester, New York area. Data obtained from weather bureau Rochester municipal airport.

the estimated consumption of straight salt is 4,340 tons or a 20.9 percent increase over the previous winter.

On this basis, 530 tons of salt (17.6 percent) were saved by using a calcium chloride and salt mixture (Fig. 3). By noting the cost F.O.B. at Weedsport for the past winter, a cost comparison is obtained, as follows:

On a basis of straight salt estimated at 4,340 tons			
	4,340 tons	$13.65/ton	$59,241.00
On using a total of 3,810 tons of calcium-salt mixture			
Salt	3,040 tons	$13.65/ton	$41,496.00
Calcium	770 tons	28.50	21,945.00
	3,810 tons	Total cost	$63,441.00

By comparing prices, the apparent increase cost resulting from the use of mixtures is $4,200. Regarding this figure, it should be pointed out that it is not logical to assume that additional salt would have accomplished results equal to those of the mixture; its superiority over salt is indicated by the tests. It is difficult to estimate expenditures, had salt alone been used.

Estimated cost increase is also offset by other savings from chemical mixtures. Eliminating handling and applying of an estimated 530 tons of salt, these savings might be:

Average load per Highway Spreader			6 tons
530 / 6	tons / tons/trip	88.3	Approx. 88 trips with the highway spreader saved

Average distance traveled per spreader load (including dead haul) 25 mi.

88 trips x 25 mi/trip - 2,200 mi saved on highway spreader this year.

To verify the mileage saved on the highway spreaders, Table 2 gives the actual number of miles traveled in each section by the highway spreaders for the past two years. By comparing these figures, it shows that up to 2,600 mi were saved by the Weedsport spreaders when compared with the Manchester Section. Likewise with

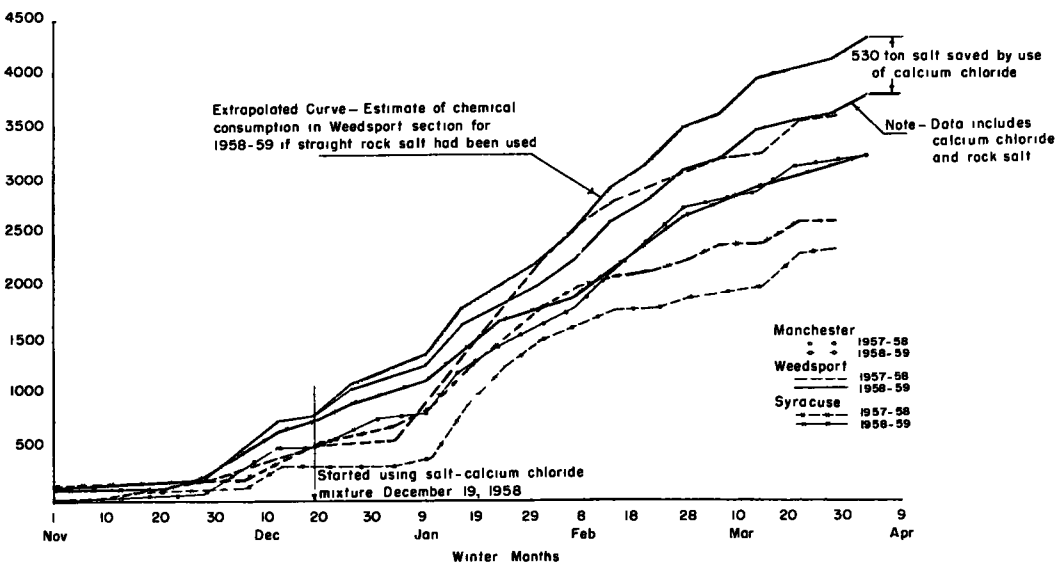

Figure 3. Accumulative curve - tons of chemicals used in Manchester, Weedsport and Syracuse sections during winters of 1957-58 and 1958-59.

the Syracuse Section, a savings of 3,200 mi may be noted. These figures verify the distance of 2,200 mi eliminated by not having to spread salt.

Table 3 gives data on manhours by the three maintenance sections during the winters of 1957-58 and 1958-59. As of this time, no data were available on the manhours in November and December of 1957, so the only comparisons that can be made are for January, February, and March for the two winters. From this Table, it can be seen that a large decrease occurred in total manhours in each section for the quarter of January to March, 1959, as compared with the corresponding period in 1958.

This large decrease in manhours for the 1958-59 winter is due to a reduction in personnel and to a change in the winter maintenance schedule from 1957-58. It should also be noted that the manhours in Syracuse Section do not include the manhours by the Syracuse Division Highway Crew, which are relied upon by the Syracuse Section for plowing operations during the winter.

The conclusions obvious from this comparison are that there is a larger decrease in total manhours in the Weedsport Section, from last year, than in either the Manchester and Syracuse Sections. If the use of chemical mixtures by the Weedsport Section has caused any of this reduction in manhours, this reduction would be the result of a decrease in overtime hours worked.

A comparison with the Manchester Section indicates a reduction of 1,504 hr for the Weedsport Section or a savings of approximately $2,940. A better comparison would be to compare overtime in each section for each year, but the records for 1957-58

TABLE 2

COMPARISON OF TOTAL MILEAGE ON HIGHWAY SPREADERS BY SECTION FOR WINTER SEASON

Section	Total Mileage On Highway Spreaders 1957-58	Total Mileage On Highway Spreaders 1958-59	Increase in Mileage 1958-59 (mi)	Increase in Mileage 1957-58 (%)
Syracuse[1]	28,100	36,700	8,600	30.6
Weedsport	37,600	42,990	5,390	14.3
Manchester	34,600	42,630	8,000	23.1

[1] Includes allowance for Division Reserve Spreader No. 338.

TABLE 3

Date	Syracuse No. of Hours	Section Accum. Hours	Weedsport No. of Hours	Section Accum. Hours	Manchester No. of Hours	Section Accum. Hours
Total Manhours Worked During Winter Season 1957-58						
November 1957		No	Information		Available	
December 1957		No	Information		Available	
January 1958	6,722	(6,722)	8,373	(8,373)	7,295	(7,295)
February 1958	5,421	(12,143)	6,810	(15,183)	6,128	(13,423)
March 1958	4,109	(16,252)	5,175	(20,358)	4,708	(18,131)
Accumulated hours for 3-month period January - March 1958.		(16,252)		(20,358)		(18,131)
Total Manhours Worked During Winter Season 1958-59						
November 1958	5,918	5,918	5,919	5,919	6,008	6,008
December 1958	5,118	11,036	5,355	11,274	6,242	12,250
January 1959	5,020	16,056	6,954	18,228	6,635	18,885
February 1959	4,515	20,571	5,475	23,703	5,114	23,999
March 1959	3,703	24,274	4,448	28,151	4,405	28,404
Accumulated hours for 3-month period January - March 1959.		13,238		16,877		16,154
Difference in accumulated hours between 1958 and 1959.		3,041		3,481		1,977

were inadequate for this purpose. For the next winter test program, it will be possible to obtain a record of overtime worked by each section for a comparison with this winter's operation.

There are other advantages obtained by the use of calcium chloride which a monetary value is nearly impossible to assign. If the use of calcium chloride results in clear and bare pavement in a shorter time, this, in turn, would result in not only less overtime for the maintenance forces, but will also result in fewer accidents and slide-offs due to slippery pavement. While no records are available in Syracuse for obtaining a comparison of the slide-offs in previous years, it is believed that there were fewer property damage reports and fewer cases of automobile slide-offs from the pavement in 1958-59 than in previous years. This results in better public relations due to safer conditions for the traveling public. Certainly time and consequently economy is realized by normal traffic flow resulting from bare pavement.

Some comparison should be made as to the relative cost of the calcium chloride and salt. Prices delivered to the Weedsport Maintenance Area for the winter season are as follows:

Calcium Chloride	$28.50/ton
Rock Salt, Grade CC	13.65/ton
Abrasives	2.00/ton

At this price of materials, the cost of a ton of calcium chloride and salt mixture at the 1:3 ratio, (by weight) is $17.36/ton. This is an increase of $3.71 per ton (27.2 percent over the cost of a ton of straight salt. As noted previously, the 530 tons of salt saved was saving of 17.6 percent. Because the addition of calcium increases the cost 27.2 percent, approximately an additional 10 percent savings should be realized from the saving in time, labor, and equipment to obtain comparable costs with straight rock salt.

Abrasives with the chemical mixture provide a combination cheaper per ton than the cost of rock salt.

Mixture Ratio:
2 parts chemical to 1 part abrasive (by volume)
Cost $10.95 per ton

This mixture, while cheaper than straight salt, proved to be an excellent all around mixture. It was used under almost all storm conditions, with greater effectiveness than straight salt, and provided abrasives for skid protection.

Based on the following weights:

Calcium chloride	60 pcf
Rock salt	75 pcf
Abrasives	100 pcf

FUTURE WINTER STORM PROCEDURES

To further compare data from the 1958-59 experiment using calcium chloride mixtures, it was decided to carry out the test program for another year. By utilizing past experience and proceeding with mixtures that have proven valuable and economical, it is believed that another winter of testing may prove that a comparable job can be obtained with a further reduction in cost.

Based upon the experiment, the following storm procedures are recommended for the 1959-60 winter season:

1. Ice and Sleet Storms: Use chemical mixture (1 to 2 parts calcium to salt by volume) with or without abrasives. The first spread on the pavement will be with clear chemical mixture. This is to be followed, if additional spreading is necessary, with a mixture of equal parts of chemical and abrasives.

2. Temperatures near 30F plus or minus and above: Use clear rock salt.
3. Temperatures in range of 25 to 30F: Use chemical mixture, with or without abrasives, depending upon the time of day and existing weather conditions.
4. Temperatures near 25F and falling: Use chemical mixture with abrasives in varying proportions, depending upon the temperature. As the temperature decreases, increase the amount of abrasive to proportions as high as one part chemical mixture to two parts abrasives. Strive to discontinue the use of chemicals and obtain a dry pavement with abrasives. They tend to blot up the moistures on the pavement and also provide skid protection for moving traffic.
5. Temperatures below 20F, and dry snow conditions: Depend on plowing operations to maintain clear pavement and discontinue the use of any chemicals.
6. For heavy snow storms, temperatures range 20 to 30F: Depending upon the temperature as noted previously, apply salt, or mixtures with abrasives to pavement at the beginning of a storm to prevent packing and bonding of snow to pavement. Continue plowing operations until storm ends and clean pavement by use of procedures 1-5.

The above procedures are intended as a guide and their use depends on the observations and experience of supervisory personnel and on the existing traffic conditions.

SUMMARY

The 1958-59 winter operations have definitely pointed to the benefits that can be obtained by the use of calcium chloride. The calcium chloride greatly speeded up the slower melting action of rock salt and a mixture of the two chemicals tends to combine the advantages of both chemicals making the mixture more effective than the use of either chemical alone. With the use of straight salt it has been felt that a great deal of melting action of the slower acting salt has been wasted due to the frequency of the plowing operations. With the calcium chloride starting the melting action immediately, many more benefits are obtained.

In summarizing the results of this test program, it should be stressed that while much was learned about the use of calcium chloride, different proportions and mixtures were experimented with, which are not always economical. With the test program being extended for another season, it is felt that the value of using calcium chloride will be further demonstrated not only by its performance, but also from the economic viewpoint. By utilizing the storm procedures obtained from the previous winter's test, it is felt that the economic's of using chemicals mixtures will be shown. The advantages of the use of abrasives in the mixtures were not fully recognized until late in the winter season and will definitely be utilized to full advantage next year.